MOUNTAIN HYDROLOGY RESEARCH

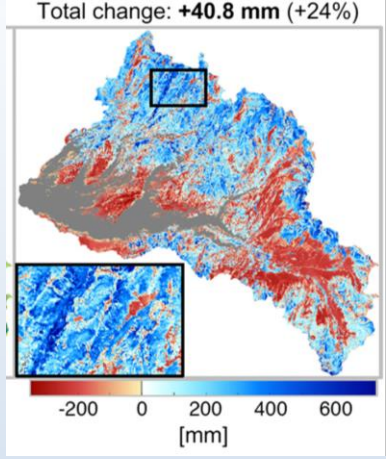
UNIVERSITY of WASHINGTON

AGU Town Hall

Jessica Lundquist

12:30-1:30, Thursday, December 12th

WRR special issue on Snow Remote Sensing



- 27 papers published and posted: https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1944-7973.SNOWEX1
- Published papers that specifically used Snow-Ex 2017 data:
  - Meyer and Skiles (ASO SfM over Senator Beck): https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2018WR024518
  - Currier (SnowEx 2017 TLS vs. ALS vs. people with poles): https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2018WR024533
  - Mazzotti (snow patterns under trees, using ASO lidar): https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019WR024898
  - McGrath et al. (ground penetrating radar): https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019WR024907

Water Resources Research
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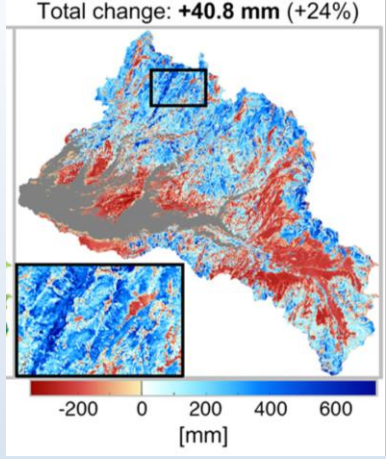
WRR special issue on Snow Remote Sensing



- 97 total papers listed in the system
  - Some are still under revision. Note from one author, "the reviews were challenging but relevant and really helped us strengthen our study. We had to work hard to respond to the reviewers but it was definitely worth!"
  - Beyond SnowEx, the collection includes many remote sensing applications globally, including improvements in photogrammetry, cloud detection, snow albedo estimation, recurring snow patterns, snow melt and refreeze, etc.

Water Resources Research
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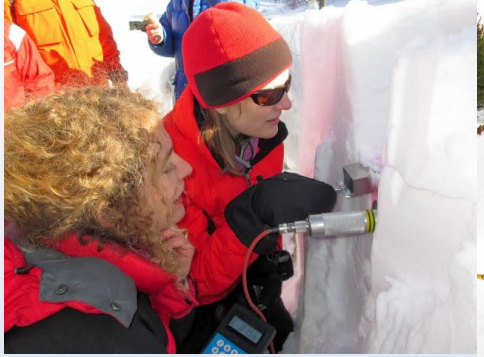
International Snow Working Group Remote Sensing (ISWGR)

- **ISWGR** – open to everyone, trying to improve snow education and international coordination
  - Election this fall, newly elected executive members Eli Deeb and Karl Rittger (joining Carrie Vuyovich, Chris Derksen, HP Marshall, McKenzie Skiles, Mel Sandells, Juha Lemmetyinen, and Nick Rutter)
  - Free to join (sign up for mailing list): http://depts.washington.edu/iswgr/contact.html




- **Snow Schools**
  - US CUAHSI Virtual University: Offered online in fall, both snow modeling (Jessica) and snow remote sensing (HP) – links to video lectures will be posted via ISWGR mailing list or website
  - US CUAHSI Snow Field School (one week intensive, open to those new to in situ measurements)
    - January 2020, led by Carrie in New Hampshire (applications closed)
    - January 2021, led by McKenzie in Utah (watch for applications next summer, early fall)
    - Future years – feel free to volunteer to get involved
  - European Snow Science Winter School
    - Typically offered in February, led by Marie Dumont in France in 2020 (applications closed)
    - Watch next fall for applications deadlines

SnowEx'17 Data Status

E. Kim & C.K. Gatebe

AGU snow town hall 2019

SnowEx'17 Data Highlights:

- SnowEx official data archive is National Snow and Ice Data Center (NSIDC) DAAC.
- Official data includes
  - rigorous quality control/user support
  - extensive metadata (machine-searchable)
  - consistent format w/other campaigns
  - documentation
- **snow.nasa.gov** -> Campaigns-> SnowEx -> Campaign data
- All major SnowEx17 datasets either published or in-progress
- Over 145,000 file downloads by >163 users in > 19 countries

SnowEx'17 Airborne Data Status

Instrument name (Airborne)	Primary data product(s)	Product Name
Cloud Absorption Radiometer (CAR)	Spectral BRDF, albedo, imagery	SNEX17_CAR
CASI-1500 Hyperspectral VNIR Imager (ASO hyperspectral imager)	irradiance, radiative forcing, snow albedo, snow grain size, snow-covered area (SCA), land surface classification	
Riegl LMS-Q1560 (ASO lidar)	surface elevation, snow depth, change in snow depth, snow water equivalent (SWE), snow density	ASO_3M_SD, ASO_50M_SD, ASO_50M_SWE
Riegl LMS-Q1560 (ASO lidar)	Lidar waveforms	Processing in progress by BSU/GSFC
PhaseOne iXU 180-R50 (ASO camera)	visible imagery	
QWIP camera	P3 thermal IR imagery	SNEX17_QWIP_ST
KT-15	P3 thermal IR brightness temperature	SNEX17_KT15_TB
P-3 video camera	P3 video imagery	SNEX17_P3V
UAVSAR (L-band SAR)	Quad Pol Backscatter, Single Look Complex Stacks	SNEX17_InSAR Available at JPL UAVSAR site
GLISTIN-A (Ka band SAR)	Backscatter, Topographic Height	SNEX17_InSAR Available at JPL UAVSAR site
SnowSAR	X/Ku backscatter, SAR imagery	final processing in progress at NSIDC
WISM radiometer (passive microwave)	brightness temperature	SNEX17_WRP

Please send updates/corrections to ed.kim@nasa.gov

SnowEx'17 Field Data Status

Instrument name (Field)	Primary data product(s)	Product Name
IceCube, IRIS	relectance, grain size, Specific Surface Area	SNEX17_SSA
DGNSS	precision locations of pits/transects/TLS	SNEX17_DGNSS1
Magnaprobe	Snow Depth	
Snow MicroPenetrometer (SMP)	force profiles	SNEX17_SMP
Snow MicroPenetrometer (SMP)	force profiles, Senator Beck basin	SNEX17_SMP2
Manual snow depth probe (transects)	Community Snow depth Measurements	SNEX17_SD
Community Snow Pit Measurements	Profiles of density, temperature, grain size, stratigraphy; photos	Snow Pit Measurements (SNEX17_SnowPits)
Meteorological stations (4x SnowEx)	met & surface energy balance	processing in progress at NSIDC
Meteorological stations (1x GMSP)	met & surface energy balance	available from J.Deems
Manual soil moisture	Gravimetric soil moisture, soil density, surface roughness, veg biomass	Processing in progress at GSFC

Please send updates/corrections to ed.kim@nasa.gov

SnowEx'17 GBRS Data Status

Instrument name (GBRS)	Primary data product(s)	Product Name
UW-Scat (X/Ku radar)	quad-pol backscatter, Mueller Matrices.	SNEX17_UWScat
6-18GHz & 25 GHz FMCW	FMCW radar profiles	SNEX17_GBB_FMCW
Ground Penetrating Radar	Ground Penetrating Radar	SNEX17_GPR, SNEX17_GPR_Raw
Radiometrics (passive microwave)	Brightness temperatures	SNEX17_SBR
Riegl VZ-4000; Riegl VZ-6000; Riegl VZ-400 (TLS)	surface elevation, vegetation elevation, vegetation structure, snow depth	
Riegl VZ-1000 (TLS)	surface elevation, vegetation elevation, vegetation structure, snow depth	SNEX17_TLS_PC_BSU
Leica ScanStation C10 (TLS)	surface elevation, vegetation elevation, vegetation structure, snow depth	SNEX_TLS_PC_CRREL
Judd snow depth sensor	15 min sonic snow depth	SNEX17_SSD
Wingscapes TimelapseCam	RGB images	Received at NSIDC
Additional datasets anticipated		

Please send updates/corrections to ed.kim@nasa.gov

NSIDC SnowEx dataset metrics (partial) through November 2019

COMPLETED DATASETS	dataset description	down loads	files dnloaded	unique users	countries
SNEX17_CAR	spectral BRDF/albedo	12	145,197	163	19
SNEX17_DGNSS1	precision gnd survey	17			
SNEX17_GPR	gnd penetrating radar	22			
SNEX17_GPR_RAW	gnd penetrating radar	9			
SNEX17_KT15_TB	airborne thermal IR	12			
SNEX17_P3V	P3 airborne video	9			
SNEX17_QWIP_ST	airborne thermal IR im	4			
SNEX17_SBR	gnd based passive mw	2			
SNEX17_SD	snow depth	30			
SNEX17_SMP	snow micro pen	32			
SNEX17_SNOWPITS	snowpits	51			
SNEX17_SSA	specific surface area	19			
SNEX17_SSD	sonic snow depth	25			
SNEX17_TLS_PC_BSU	terrestrial laser scans	10			
SNEX17_TLS_PC_CRREL	terrestrial laser scans	6			
SNEX17_UWSCAT	gnd based X/Ku radar	18			
ASO_3M_SD	ASO snow depth 3m	68	2309	135	15
ASO_50M_SD	ASO snow depth 50m	51			
ASO_50M_SWE	ASO swe 50m	46			
SNEX17_InSAR	UAVSAR				
SNEX17_InSAR	GLISTIN-A				

Note: not a complete list of all SnowEx 17 datasets

THANKS:

- Data providers from SnowEx 2017
- NSIDC/Tanner, Heightley, Moth, et al,
- NASA/HQ/J. Entin

- **snow.nasa.gov** -> Campaigns-> SnowEx -> Campaign data.

NASA SnowEx Science Plan:

Assessing Approaches for Measuring Water in Earth's Seasonal Snow

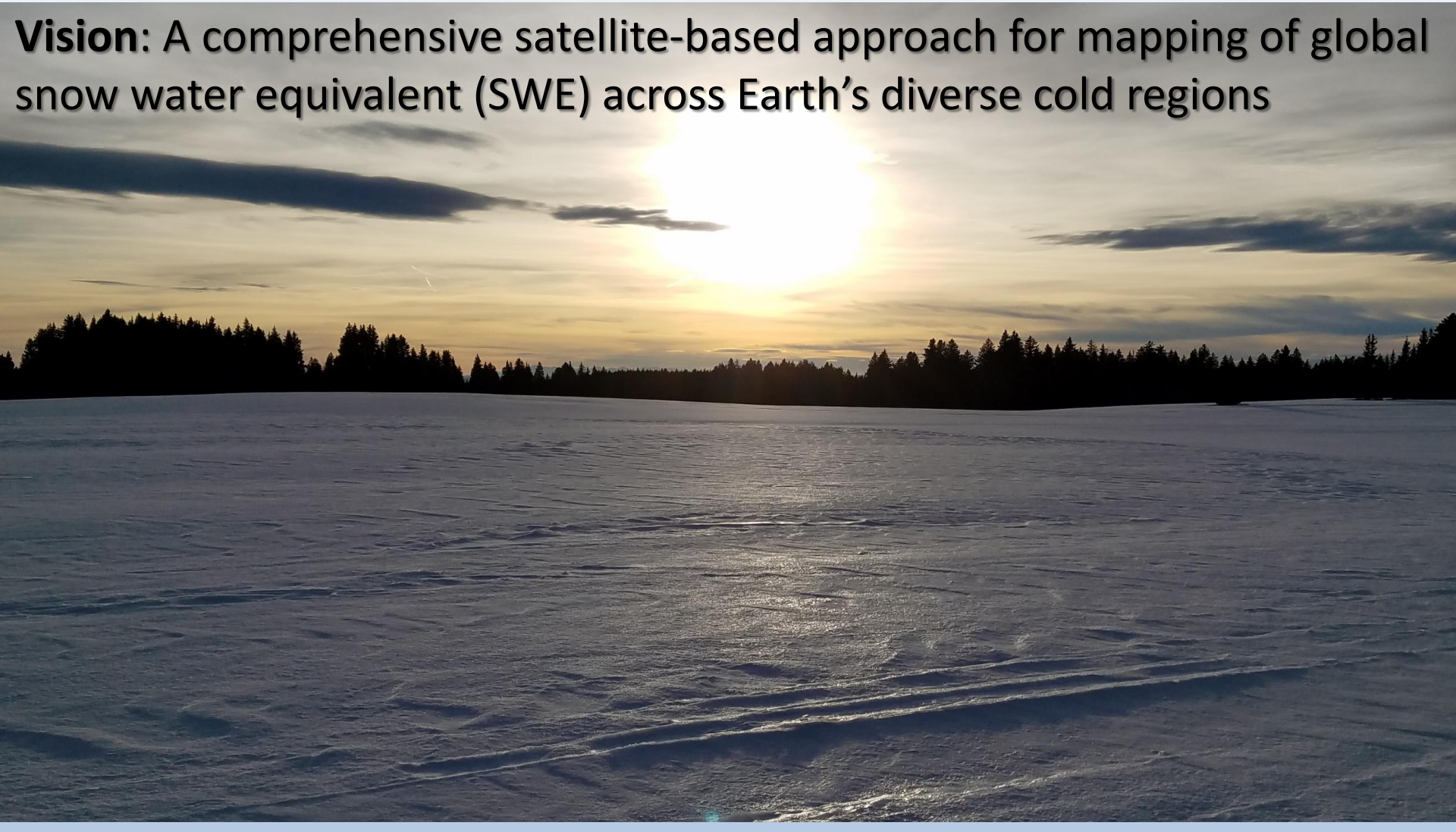
Mark Raleigh and Mike Durand

On behalf of the Science Plan Working Group: Charles Gatebe, Ed Kim, Noah Molotch, Thomas H. Painter, Melody Sandells, and Carrie Vuyovich

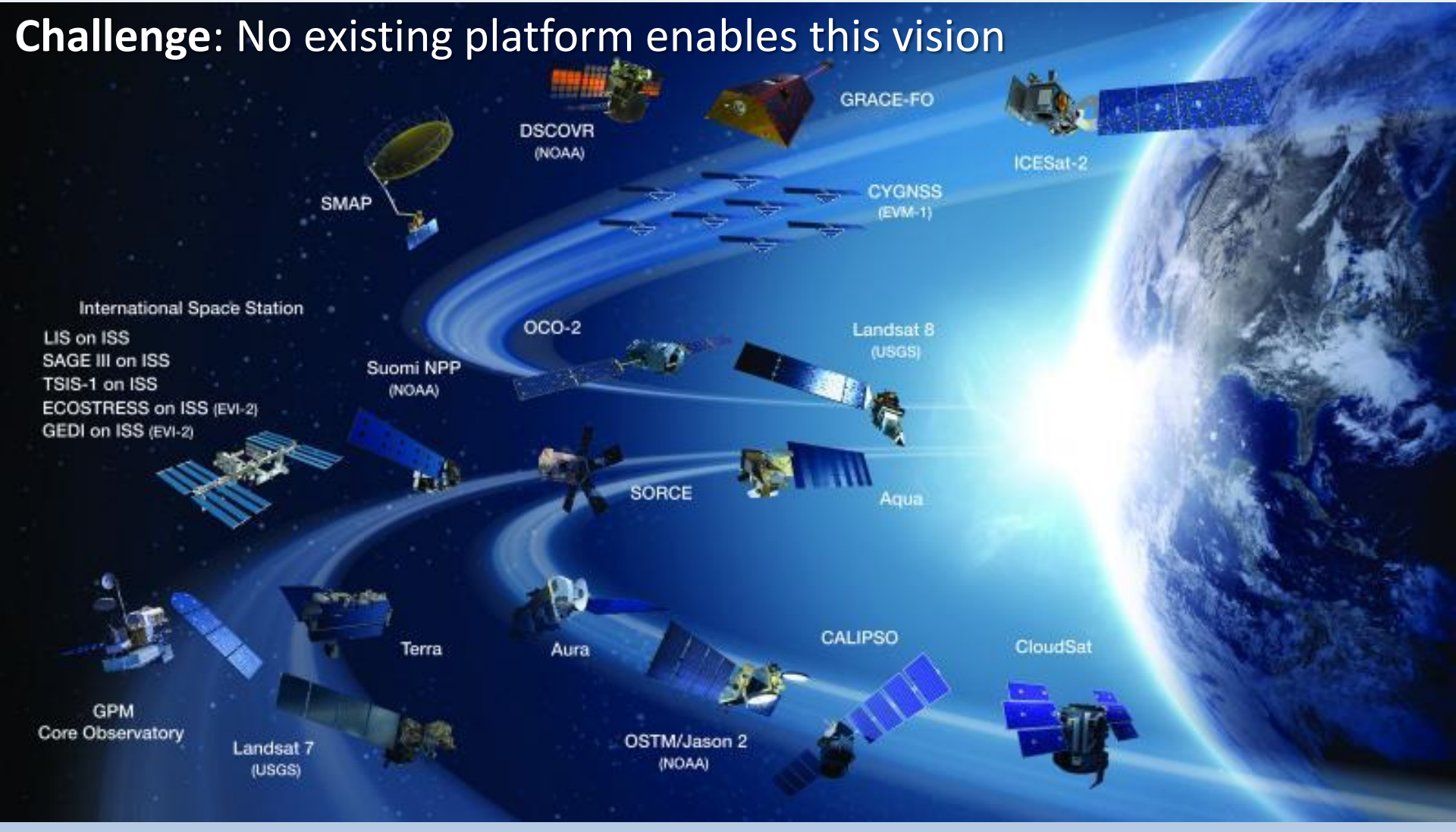
AGU100 ADVANCING EARTH AND SPACE SCIENCE

FALL MEETING

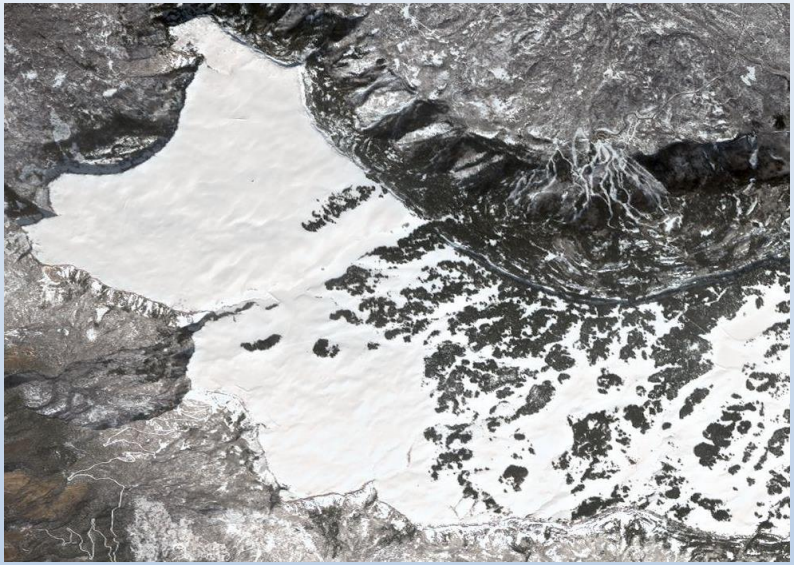
San Francisco, CA | 9–13 December 2019

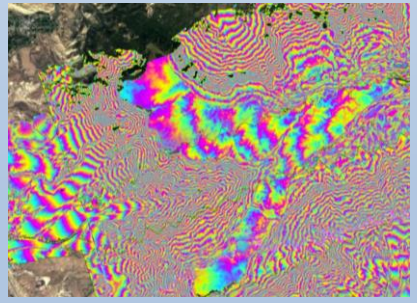

Vision: A comprehensive satellite-based approach for mapping of global snow water equivalent (SWE) across Earth's diverse cold regions

Challenge: No existing platform enables this vision



Opportunity: New measurements and new missions





How do we get there?

The optimal approach and combination of sensors/models is unknown for mapping SWE globally.

Need: A community effort to compare and combine emerging and existing remote sensing, modeling, and assimilation to identify optimal strategies for mapping SWE and related snow properties.

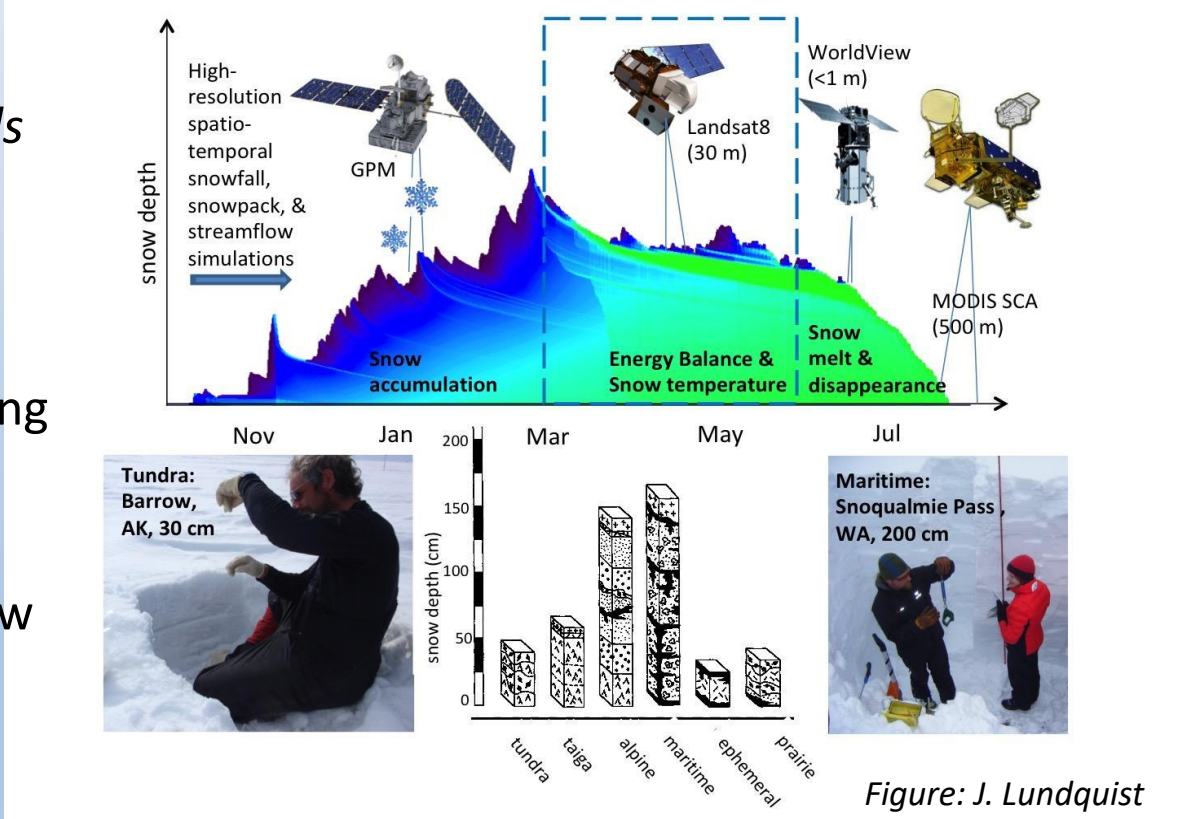


Figure: J. Lundquist

NASA SnowEx

- Program funded by NASA Terrestrial Hydrology Program to address the most important gaps (technology, science) in snow remote sensing
- **Goal**: Lay the groundwork for a future satellite mission (e.g., decadal survey) with capabilities to measure snow globally (with focus on SWE)
- **Approach**: Coordinated airborne and ground field campaigns with a variety of measurement techniques and different environments

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SnowEx Science Plan

- **Purpose**: Support decision making for future SnowEx campaigns. Provide guidance to implementation teams
- **Scope**: Set priorities; implementation left to implementation team
- **Format**: Charge was received from Jared Entin, THP program manager. Structured around articulating several “gaps”.
- **Focus**: Where are there opportunities to solve problems, better understand our measurements, models, algorithms etc., and push things forward?
- **Audience**: everyone interested in SnowEx activities, from Program managers to working groups e.g. iSWGR, to the broader community
- **Status:** This is a living document that seeks community input.

Identifying SWE techniques

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SNOWEX

Tables were populated via community workshops, discussions with experts, and literature.

Some subjectivity is admittedly present.

- Demonstrated capability
  Uncertainty quantified
- Potential capability
  Some uncertainty quantified
- Potential capability
  Uncertainty not quantified
- No capability

		Snow Observation			Gap Capabilities						
Type	Snow sensing Technique	Snow Depth	SWE	Melt	High-Res	Wet snow	Deep Snow	Forests	Complex Terrain	Shallow Snow	Clouds
SWE via snow depth	Lidar										
	Ka-band InSAR										
	Dual band Ku/Ka altimetry										
	SfM/Stereo Photogrammetry										
	Wideband Radiometer										
Volume scattering	Ku-band SAR										
	Passive Microwave										
Signal interferom	L-Band InSAR										
	Signals of Opportunity										
Airborne / ground	FMCW Radar										
	Gamma										

Proposed Prioritizations

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Mission Critical

- Ku band
- L-band InSAR
- Ka-band InSAR
- Modeling and DA
- Lidar

Crucial

- Passive Microwave
- Albedo Imaging
- Thermal IR Imaging

Important

- Photogrammetry
- Airborne FMCW

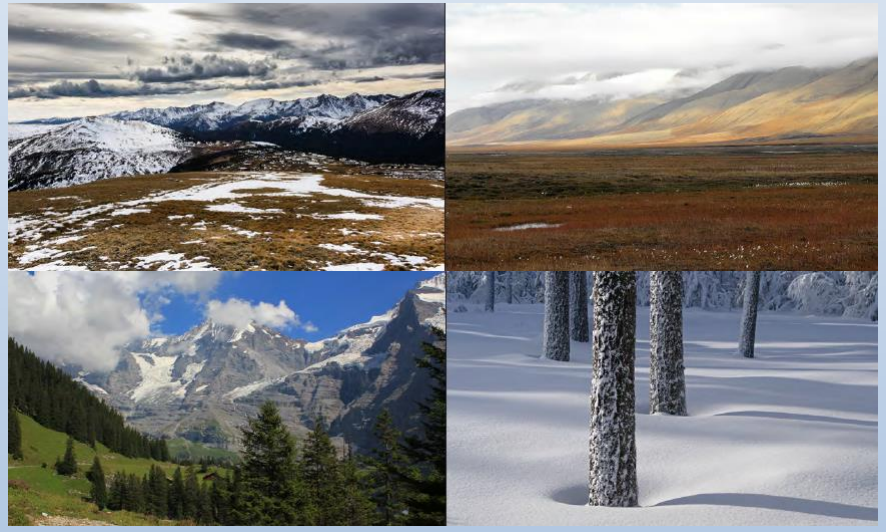
Beneficial

- Gamma
- SoOP
- Autocorrelation radiometer
- L-band passive

After the publication of Lievens et al. N Comms 2019, we have begun adding C-band SAR to planning and consideration in the Science Plan.

Identified Gaps

- Forest Snow
- Maritime Snow
- Mountain Snow
- Prairie Snow
- Snow Surface Energetics
- Tundra Snow
- Wet Snow



Recommended Campaigns

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SNOWEX NASA

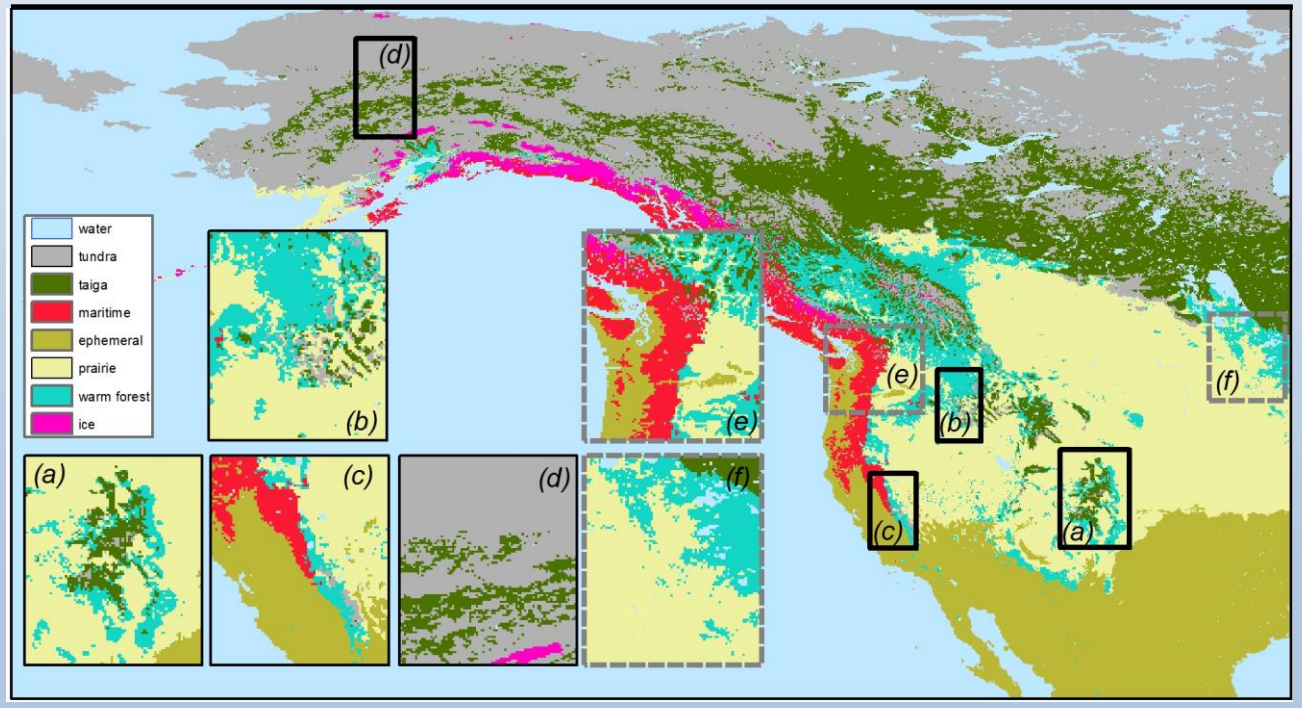
Notional study domains and snow climates (Liston/Sturm classification)

Organize annual campaigns to address one or more gaps:

2017: Forests
2020: Forests, mountains, wet snow.

Remaining:
- Prairie
- Tundra, Boreal
- Maritime

Leverage other community activities, e.g. ASO, ABoVE



SnowEx is helping to close the gaps

- Huge strides on L-band gap expected from the 2020 datasets. Need tundra & taiga
- Ku-band data will help address mountain snow and tundra snow. Need prairie snow.
- Ka-data will help address unwrapping in mountain environments.
- Next: Use modeling and assimilation with combinations of datasets

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Status and Next Steps

- Current draft available (v 1.7):
  - go.osu.edu/snowex-sp (or QR code)
  - Changes after feedback from last year's townhall:
    - Perspective on C-band SAR
    - Perspective on spatial scale
    - Motivating questions for linking modeling and assimilation to observations

- Questions/comments? Please contact:
  - **Mike Durand** (durand.8@osu.edu)
  - **Mark Raleigh** (mark.raleigh@colorado.edu)

NASA SnowEx 2020: *Updates*

Organizing Team: HP Marshall, Carrie Vuyovich, Jerry Newlin, Chris Hiemstra, Ludo Brucker, Kelly Elder, Jeff Deems
Time Series Leads, Aircraft Teams, Field Teams, Partnerships

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SnowEx 2020

The SnowEx 2020 Campaign consists of coordinated airborne and field-based experiments in the Western U.S. to test instruments under a variety of snow conditions. This effort includes two major components:

1. **A time series experiment with UAVSAR**
   - 13 sites, spanning 5 states
   - December 18, 2019 to May 6, 2020, with weekly to bi-weekly (fortnightly) aircraft overflights and field campaigns
   - Airborne LiDAR for calibration/validation
2. **A detailed experiment on Grand Mesa, Colorado**
   - 5-day snow-off campaign November 4-8, 2019 (*COMPLETED*)
   - 10-day snow-on campaign January 27 –February 7, 2020

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Alignment with THP16 Science Plan

SnowEx 2020: Responds to 6 out of 7 Science Plan Gaps

- Snow climates (Forest, mountain, prairie, maritime)
- Wet snow, accumulation and melt (time series)
- Surface energetics (surface temperature)

SnowEx 2020: Responds to all Science Plan *Mission Critical, Crucial*, *Important* priorities

- L-band InSAR (UAVSAR)
- X-, K-, Ka-band Passive microwave (SWESARR)
- X-band, dual Ku-band SAR (SWESARR)
- Ka-band InSAR (GLISTIN-A)
- LiDAR (ASO, Quantum Spatial, CRREL HeliPod)
- Thermal IR (UW)
- Hyperspectral imaging (ASO, Quantum Spatial, SaraniaSat)
- Modeling / Data Assimilation (SEUP, NOHRSC)
- Photogrammetry / Structure from Motion (airborne and satellite based)
- FMCW radar (similar to IceBridge SnowRadar; University of Alabama)

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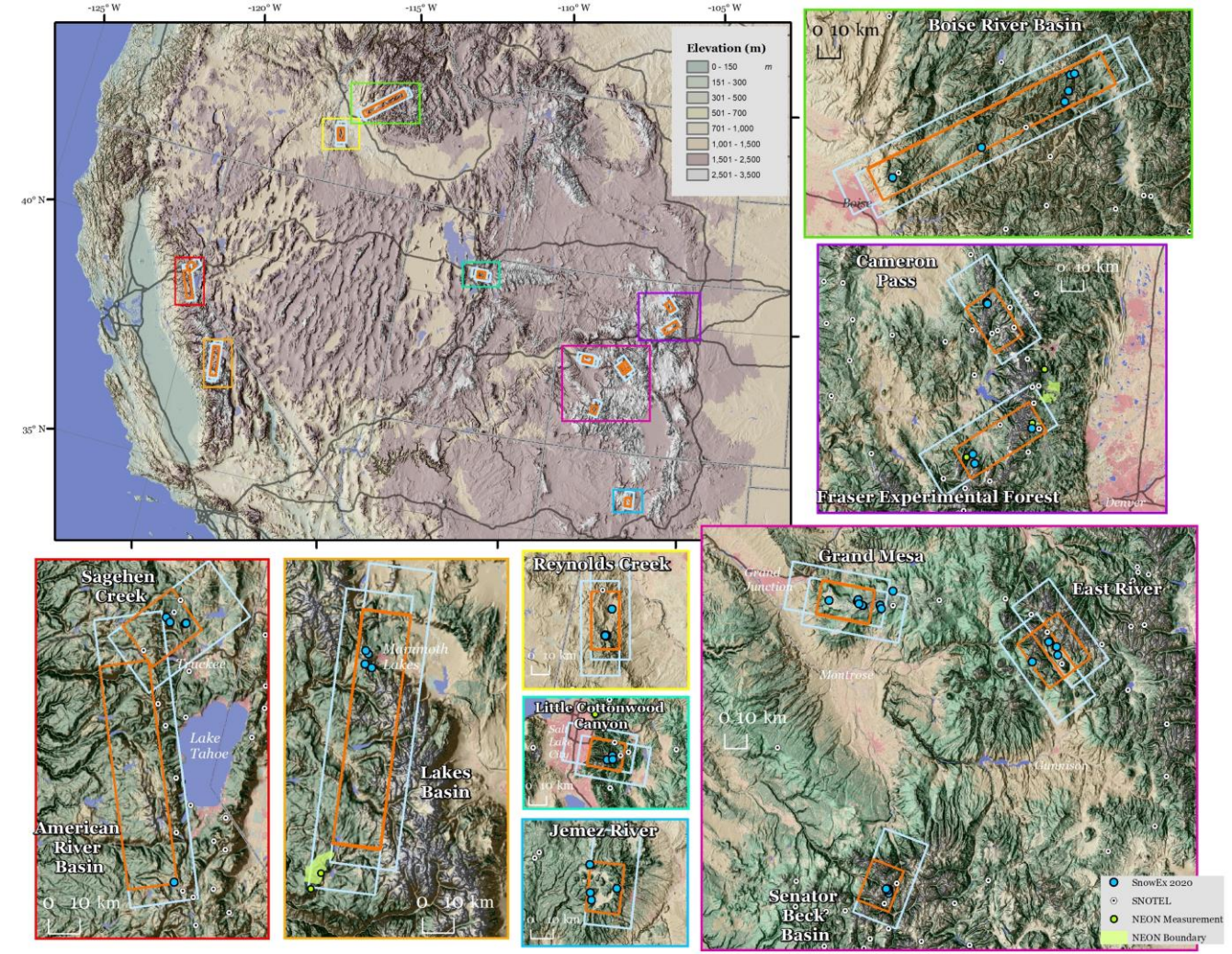


Sites cover a wide range of snow climatology, land cover, and topography

Leveraging THP16/17 projects, Critical Zone Observatories (CZO) sites, LTER sites, and other long term observations in critical watersheds

Chris Hiemstra, 2019]

SnowEx 2020 – Time Series

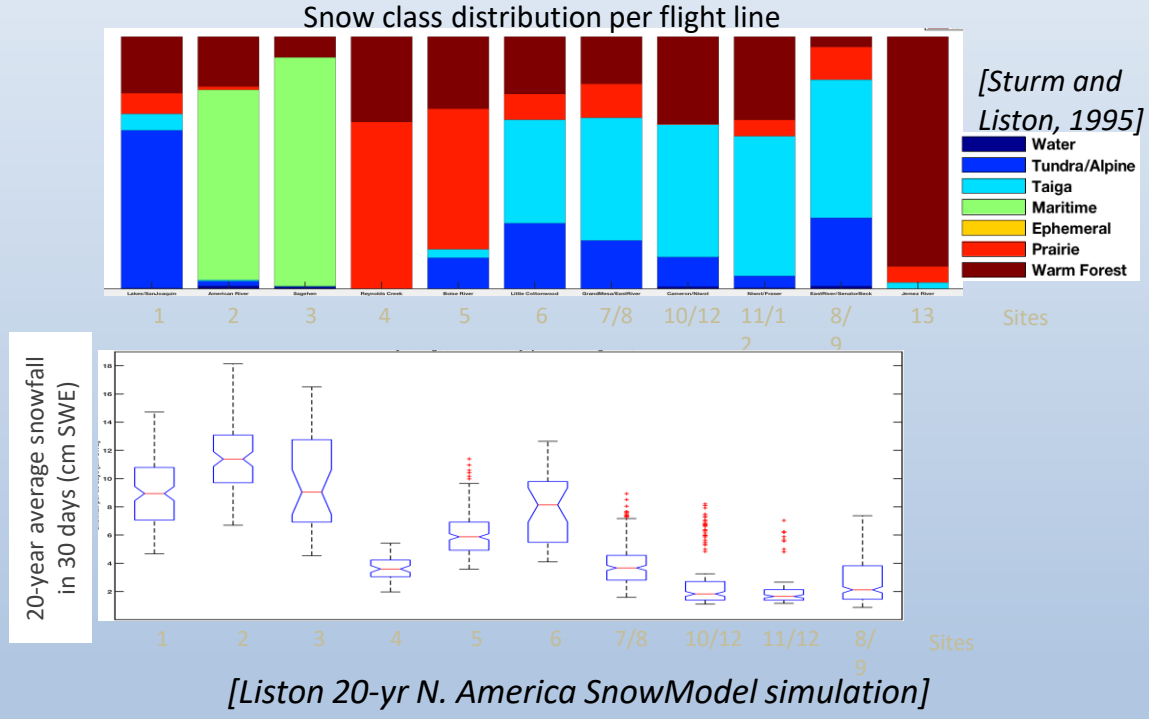
Focus on variability of snow and landscape conditions throughout the accumulation and melt season.

Ground observations of:

- Change in snow depth and SWE
- Snow stratigraphy, density, and liquid water content
- Ground-based radar (CSU, UNM, BSU)
- Terrestrial LiDAR (CRREL, BSU)
- Field spectrometer (Univ UT, UNR)

Airborne observations of:

- L-band InSAR (UAVSAR)
- Airborne LiDAR (ASO, CRREL, etc)
- Ka-band InSAR (GLISTIN-A (CA))



[Liston 20-yr N. America SnowModel simulation]

SnowEx 2020 – Grand Mesa

Primary Objectives:

1. Collect data needed test and validate SWE retrieval from active and passive microwave sensors
2. Collect thermal IR data to assess the value of kilometer-scale satellite IR observations (e.g., GOES-16/17) for snow energy balance modeling

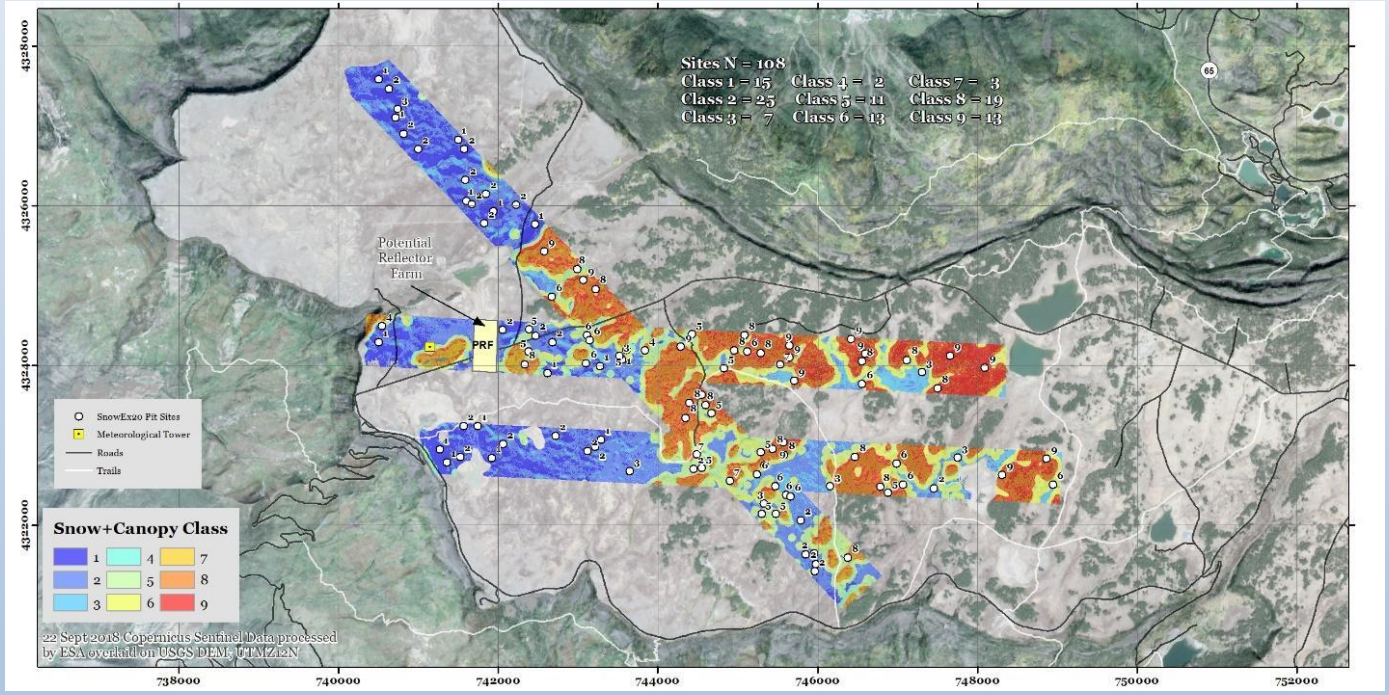
- Focus on flat, open shrubland and meadows and transitioning into forests
- Ground observations of:
  - Snow depth and surface temperature spatial variability
  - Vertical profiles of snow stratigraphy and microstructure

Grand Mesa Airborne instruments

Airborne observations of:

- X-, dual Ku-band radar (NASA GSFC SWESARR)
- X, K-, Ka-band radiometer (NASA GSFC SWESARR)
- Thermal IR (U. of Washington)
- LiDAR and Hyperspectral (Quantum Spatial)
- L-band InSAR (UAVSAR)
- FMCW Snow Radar (U. of Alabama)
- Gamma Airborne Survey (NOAA NOHRSC)

Grand Mesa Ground Sampling locations



Ground Observations:

- Snow depth
- Snow surface roughness
- Stratigraphy
- Density
- Wetness
- Temperature
- Grain Size
- Soil Characteristics
- TLS, Magnaprobe
- GPR, FMCW
- SMP, IceCube/IRIS
- Snow Casting / Micro-CT
- Soil moisture, soil temp
- COSMOS soil mois./SWE

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Current Status:

1. **Time Series**
   - L-band InSAR, LiDAR, Hyperspectral - confirmed
   - GLISTIN-A flight planning/schedule in progress
   - All participants confirmed, gear shipped to sites
   - Online data entry system completed (NSIDC)
   - Training of field teams in progress, first flight Dec 18th
2. **Grand Mesa**
   - Snow-free TLS surveys and time-lapse camera deployment completed (September 2019)
   - 5-day background SWESARR campaign completed (November 2019)
   - L-band InSAR, LiDAR and Hyperspectral flights - confirmed
   - University of Alabama FMCW SnowRadar, NOAA NOHRSC Gamma – confirmed
   - SWESARR, UW Thermal IR – NASA approvals in progress for Jan/Feb IOP
   - All participants confirmed
   - 10-day snow-on campaign January 27 –February 7, 2020

SnowEx 2020 – Current Collaborations/Coordination

In situ

Bi-weekly in situ sampling (Colorado, Idaho)
Natural Resources Conservation Service (NRCS)

Airborne

LiDAR flights (East River, Colorado and San Joaquin/Lakes, California)
ASO

Helipod LiDAR/thermal infrared (Boise River Basin, Idaho)
U.S. Army Corps of Engineers, CRREL

UltraWideBand radar (2-18 GHz) (Grand Mesa, Colorado)
Uni. of Alabama

Signal of Opportunity (SoOp) tower experiment (Fraser, Colorado)
JPL / U.S. Forest Service

Gamma flights (Colorado, possibly other states)
NOAA National Operational Hydrologic Remote Sensing Center (NOHRSC)

Satellite

Stereo satellite imagery (e.g., World View, TerraSAR-X)
U. of Washington, U.S. Army CRREL

Sentinal-1/2 C-band SAR
FMI, KU Leuvens (will also provide 1km snow depth products)

Modeling

Several modeling efforts focused on most sites (e.g., NOHRSC; Snow Ensemble Uncertainty Project – SEUP)

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SnowEx 2020


NASA SnowEx 2020
Experiment Plan

Draft (July 2019)

NASA

Draft Experiment Plan:

https://tinyurl.com/y4r6oz9d

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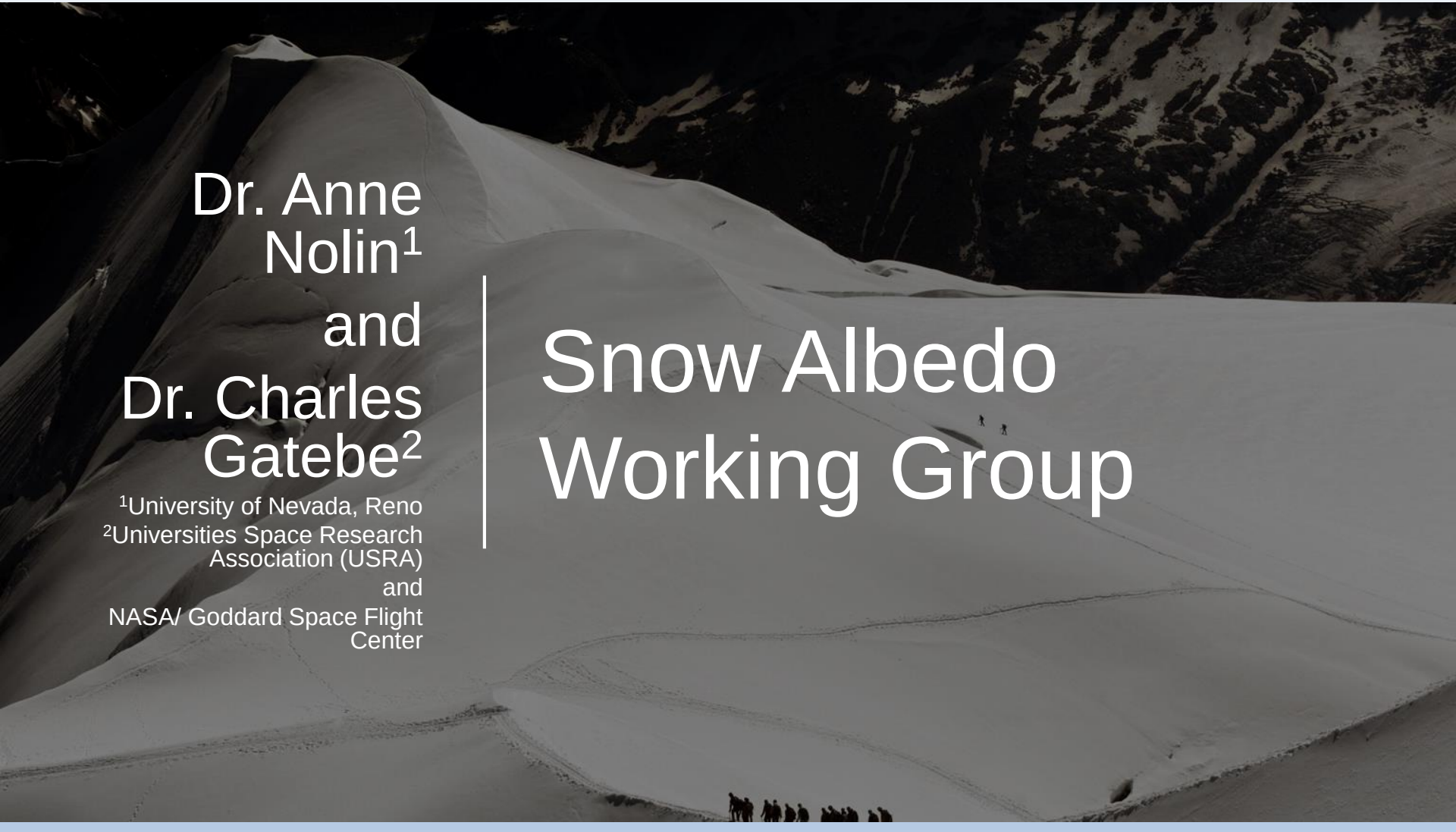


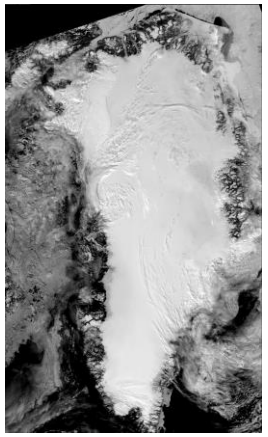
Snow Albedo Working Group

Dr. Anne Nolin[1]
and
Dr. Charles Gatebe[2]

[1]University of Nevada, Reno
[2]Universities Space Research Association (USRA)
and
NASA/ Goddard Space Flight Center

Snow Albedo

- Essential climate and hydrology variable
- High variability, high uncertainty
- Challenging measurement
- Inaccurately represented in models

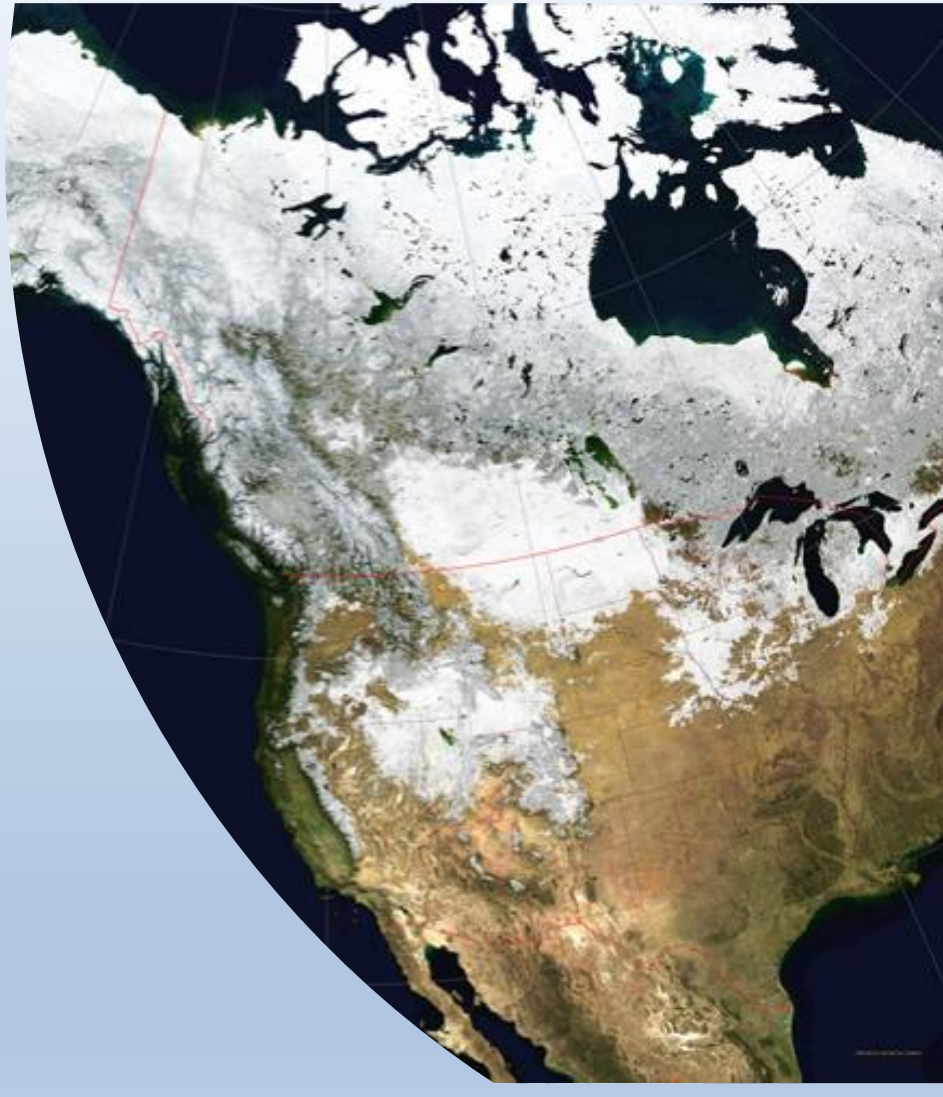


Working Group Efforts

- Create strategic plans to address the challenges of measuring and modeling snow albedo
- Strengthen albedo component of SnowEx, especially for snow-forest interactions
- Develop a community workshop in summer, 2021
- Work closely with SBG group on mission concept
- Expand international partnerships

Recent Proposal to NASA THP for a Snow Albedo Scoping Study to Address these Questions:

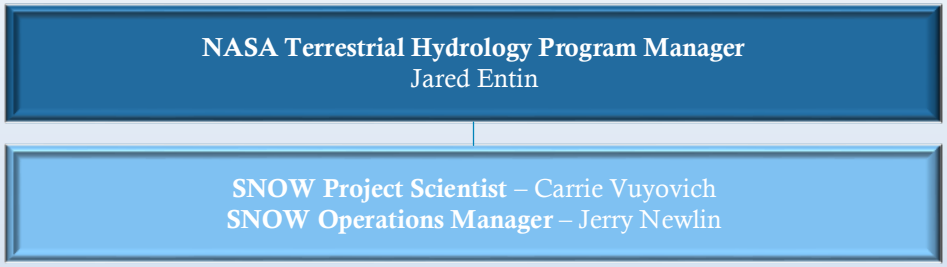
1. What is the current **state of knowledge** on snow albedo?
2. What are the current **measurement uncertainties** for snow albedo across different land cover types, snow climates, topographic complexity, and seasons?
3. What **impacts** do model biases in snow-covered surface albedo have on simulated climate? How are these impacts sensitive to location, timing and/or magnitude of albedo biases?
4. What **measurement and modeling strategies** can be used to reduce the uncertainty?



SnowEx Organization, Announcements and News

Jared Entin
Terrestrial Hydrology Program Manager
NASA Headquarters

NASA's Terrestrial Hydrology Program (THP) is supporting the Earth System Science community to improve global snow estimation, understanding snow-related processes and remote sensing. This support includes: 1) conducting a multi-year series of snow campaigns, called SnowEx, to collect airborne sensor observations and ground measurements; 2) enabling modeling and trade studies to support snow satellite mission designs; and 3) sponsoring community meetings and training opportunities, especially for early career scientists.



Carrie Vuyovich will serve as the Lead Project Scientist in support of the THP Snow program.

- She, with support from the community, will:
- Lead the development of a Roadmap that describes the activities and a schedule over the next decade for meeting overall snow program goals and objectives.
- Develop a process for evaluating community-suggested field activities on whether they address gaps identified in the SnowEx Science Plan and Decadal Survey and how they fit within the THP Snow Roadmap.
- Develop a Community Structure, which identifies topic areas and roles needed to inform the Roadmap and help assess potential activities. This includes:
  - Reaching out to community members to contribute and lead various areas
  - Providing information and opportunities to people looking to volunteer
  - Develop and Execute a plan to transfer leadership of the SEUP working group over to other members to continue
- Develop Communication Strategy to keep the snow community informed on planning and activities. This will include updating the snow.nasa.gov website, planned community meetings, regular telecons, and working with iSWGR and other groups to disseminate information.
- Establish community populated planning and exploratory groups to evaluate options for future winter activities.

THP Snow Program

Future Planning and Activities

Carrie Vuyovich

NASA / Goddard Space Flight Center

SnowEx 2019 Workshop
17 – 19 Sept 2019, Baltimore, MD

Objective: Meeting held to discuss SnowEx results and planning for future SnowEx activities, based on recommendations from the SnowEx Science Plan

- 93 Attendees
- 22 Presentations
- 36 Posters
- Presentations and notes available online:

https://snow.nasa.gov/workshops/snowex/2019

SnowEx 2019 Workshop
17 – 19 Sept 2019, Baltimore, MD

21 "1-pagers" submitted:

Break-out groups on 2nd day to discuss 3 potential activities based on submissions

1. Maritime
2. Prairie
3. Tundra/Taiga

Other outcomes and recommendations:

1. Albedo working group
2. Recommendation for data availability after campaigns
3. Modeling/Observing System Simulation Experiment (OSSE) to support snow mission
4. Test bed sites

THP Snow Program

Next Steps:

- Develop a Roadmap for THP Snow
- Develop a process to evaluate activities using the roadmap and SnowEx Science Plan to guide needs and decisions.
- Continue to quantify uncertainty of various remote sensing techniques in different conditions
- Explore candidate field campaigns and define common field campaign components
- Define short- and long-term goals of modeling/OSSE work in overall snow program

THP-Snow Roadmap

DRAFT

Current state of science and capabilities

Gaps identified in SnowEx Science Plan and Decadal Survey

SnowEx 2017
- Airborne lidar validation
- L-band InSAR in warm forest
- Surface energetics in warm forest and mtn snow
- GPR provides accurate snow depth observations.
- Impact of forests on snow processes

SnowEx 2020
- L-band InSAR time series
- Active/passive microwave
- Thermal IR

SBG Study Complete

Earth Explorer Mission Proposal call

SnowEx 2021

SnowEx 2022

SnowEx 2023

Data analysis, algorithm development, etc.

Snow Testbed Planning

Snow Test bed Implementation

Modeling

OSSE, data assimilation, scaling studies

Model Intercomparison Study

Technology Development

Machine Learning

2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029

F M F R F M R F M F R

THP-Snow Science Goals & Objectives:

Global measurement of snow

To understand:

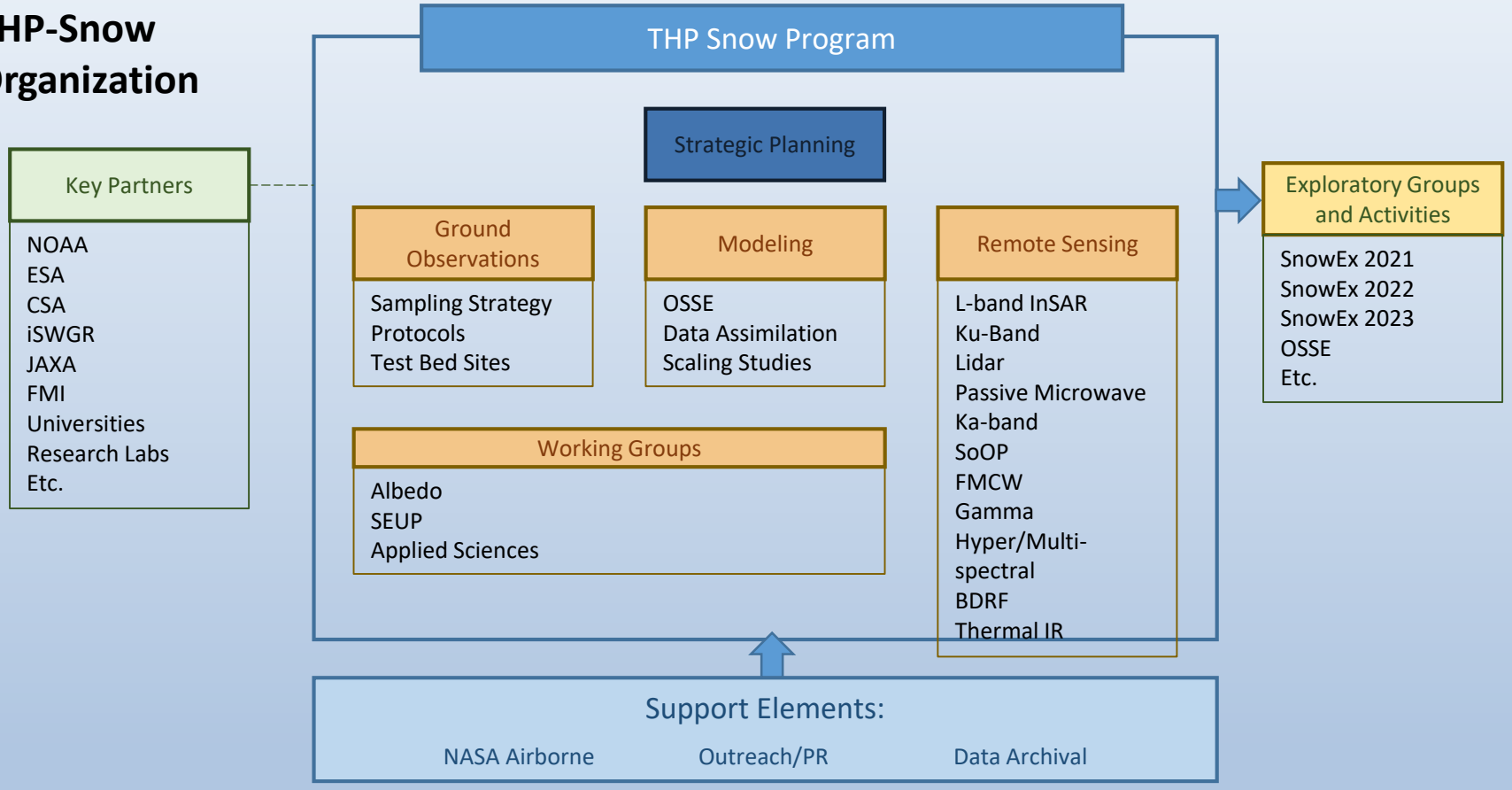
1. Total water storage in Earth's seasonal terrestrial snow
2. Spatial distribution of snow in various landscapes and snow classes
3. Temporal evolution of snow throughout the season.

THP ROSES Solicitation

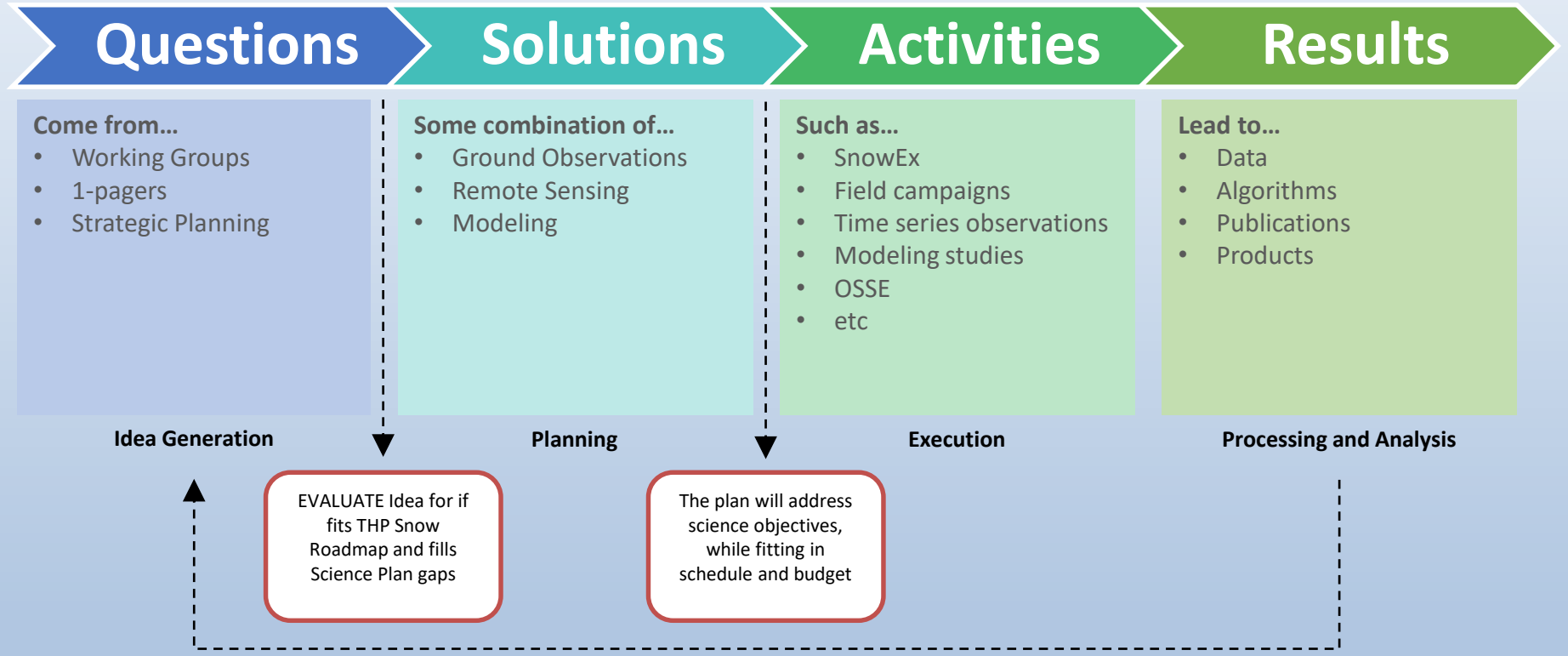
Snow School: Field (F); Modeling (M); Remote Sensing (R)

Community Meeting

THP-Snow Organization



THP-Snow Evaluation Process



THP Snow Program

Upcoming activities:

In parallel, and based on outcome of Baltimore meeting:

- Planning Groups to start evaluating field campaign options for 2020-2021
  - Albedo, Prairie
  - Small scale
  - Options presented by 1 Mar 2020, decision made by 1 Apr 2020
- Exploratory Groups to start evaluating options for 2021-2022
  - Alaska Tundra/Taiga
  - Options presented by 1 July 2020
- Evaluate Modeling/OSSE to support field activities

Thanks!

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Snow.nasa.gov

Grand Mesa, CO, November 2019